# THE REPRESENTATION OF COMMAND AND CONTROL (C2) DECISION MAKING IN COMBAT SIMULATIONS:

## C2 Representations in the Naval Simulation System (NSS)

Prepared

for

DMSO C2 Representation Workshop

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# OUTLINE

- NSS BACKGROUND
  - Design Overview
  - Targeted Users and Uses
  - Object Taxonomy
  - Architecture
- C2 TERMS OF REFERENCE RESPONSES
  - Simulated Battle Context of Command Decision Making
  - Decision Process
  - Simulated Support to the Decision Process
  - Architectural Aspects of Simulations Representing Information Operations
  - Other Issues
- SUMMARY

# NSS BACKGROUND - 1

- **Purpose:** Support Naval studies and analyses, decision support applications, and training. Constructive and virtual modes of operation.

- **Design Features:** Object-oriented;

  Monte Carlo;

  Multi-resolution;

  Entity level (with some aggregation);

  Motion in 3D on a spherical earth;

  Explicit treatment of command structure, operational plans and tactics, data fusion (perception), communications, sensors, weapons, and countermeasures.

- **Architectural Compliance:** HLA (FY-96)

  JMCIS (FY-97)

# NSS BACKGROUND - 2

- Targeted Users: OPNAV N81, Joint Staff J-8/WAD, CINCPACFLT

- Targeted Uses: Analysis/Assessment/Acquisition
  - Investment Balance Review (IBR) assessments
  - Joint Mission Area (JMA) assessments
  - Cost and Operational Effectiveness Analyses (COEAs)

  Fleet Operations Planning/Decision Support (via JMCIS)
  - Command assessment of operational plans
  - Rapid alternate course of action (COA) evaluation
  - Fleet command requirements assessment

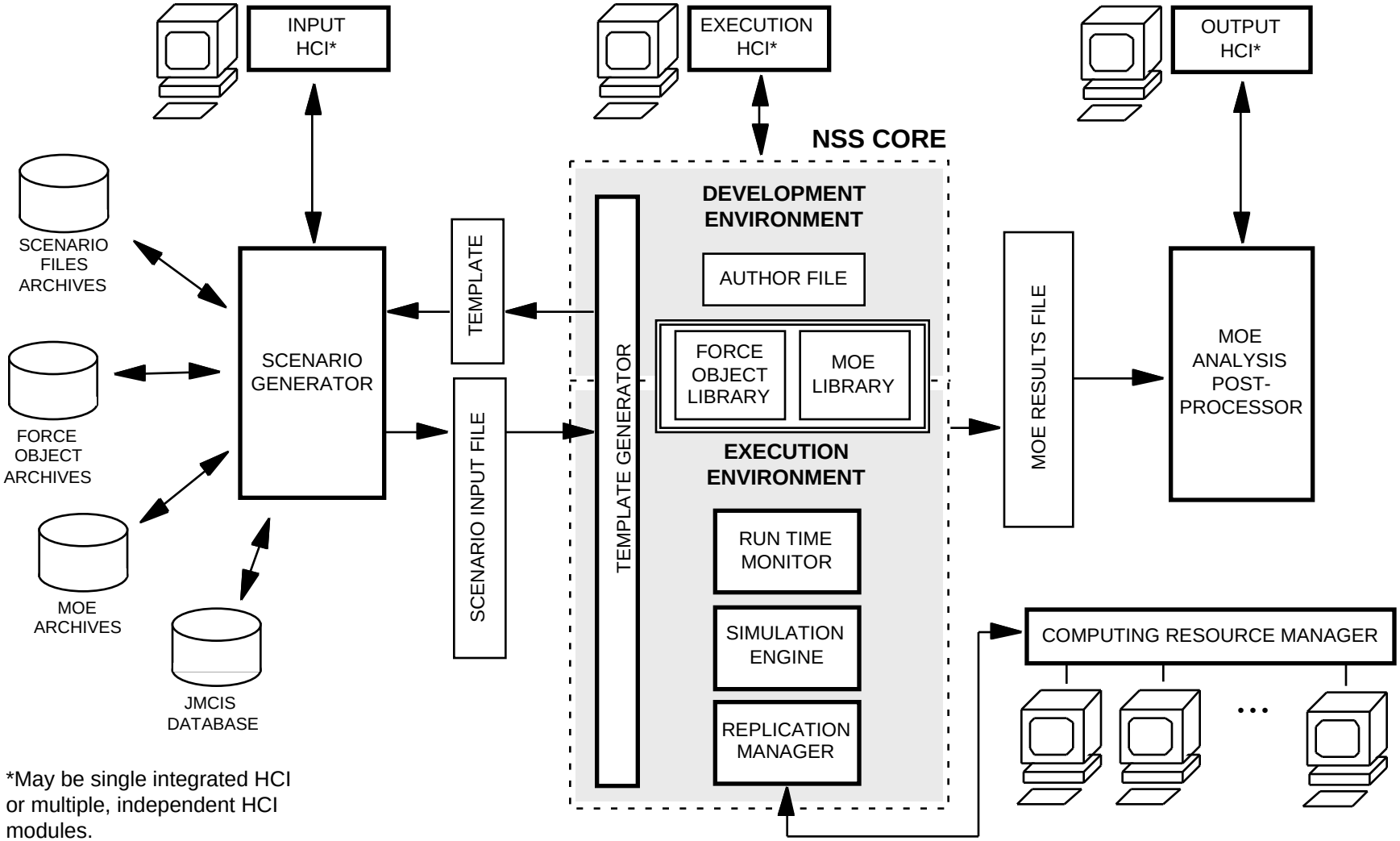
  Man-in-the-Loop Simulation
  - Analyst interactive mode of operation

# NSS BACKGROUND - 3

## NSS Object Taxonomy

# NSS BACKGROUND - 4

## NSS Architecture




*May be single integrated HCI or multiple, independent HCI modules.

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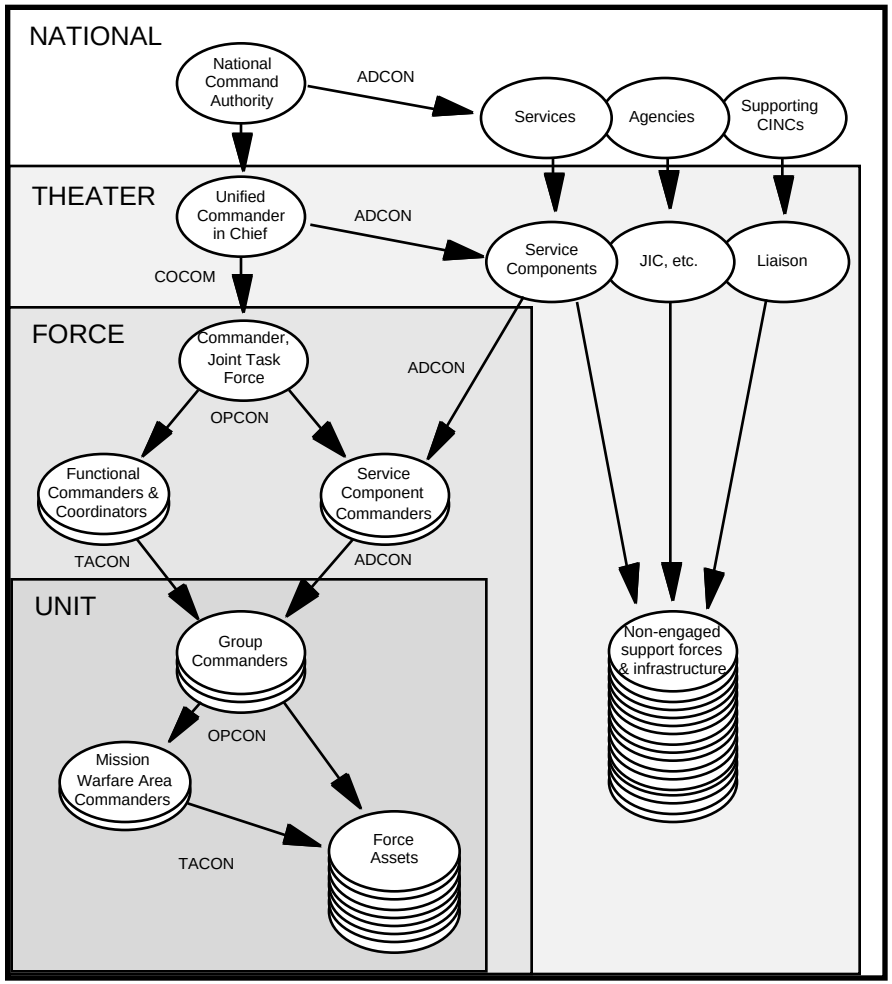
# C2 TERMS OF REFERENCE QUESTIONS

## I. SIMULATED BATTLE CONTEXT OF COMMAND DECISION MAKING

- **Level of Decision Representation.** At what echelon levels does your simulation represent the Command Decision Process? Does it include the platform level where command decisions are often those of battle engagement management (position/target selection)? Or does it also represent higher echelons of command were decisions are based on longer term battle predictions and focused on resource management?
- **Representation of Current Battle State.** How does your simulation represent the command's perception of the current battle state at each decision making echelon? Is it represented as "ground truth" or is the knowledge a result of "situation reports" from friendly forces and intelligence resources? What are the key parameters of this perceived battle state?
- **Representation of a Friendly Battle Plan.** Is the decision making process done in the context of a battle plan or objective in your simulation? If so, what software constructs (rule bases, finite state machines, decision tables etc.) are used to represent these plans/objectives in your simulation?
- **Representation of Enemy Objectives.** How are the perceived battle objectives of the enemy represented in your simulation? Are they "known" to simulated decision makers on a global basis within the simulation or are they dependent on sensor and situation reports? At higher echelons, are enemy activities represented in the context of support/strategic friendly battle objectives?

# C2 TERMS OF REFERENCE RESPONSES

## I(1). Level of Decision Representation

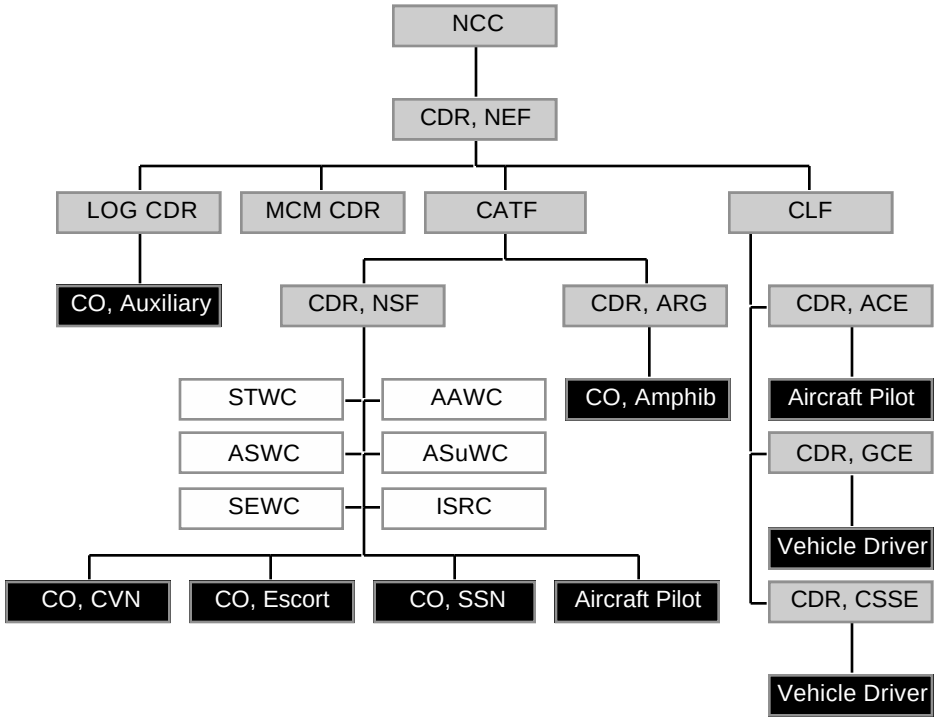



**NSS Capability:**

- National/Theater Levels:
  - User specified order of battle (OOB).
  - User specified command structures.
  - User specified time phased arrival of forces.
- Force/Unit Levels:
  - Fully dynamic and responsive treatment of commanders and the command decision process.
- Complicated command structures may be defined using three generic commander types:
  - Group Commander,
  - Warfare Mission Area (WMA) Commander,
  - Asset Commander.

# C2 TERMS OF REFERENCE RESPONSES

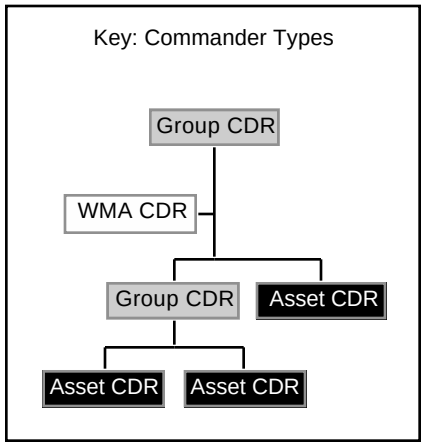
## I(1). Level of Decision Representation




**NSS Command Structures:**

NSS represents command decision-making within the context of user-defined hierarchical command structures composed of three generic commander types: **Group**, **WMA**, and **Asset**.

Functionality associated with these commander types is discussed below.



# C2 TERMS OF REFERENCE RESPONSES

## I(2). Representation of Current Battle State

Military operations are heavily **information driven**. NSS explicitly represents the systems and system architectures which are used to collect and disseminate this information. Representation of intelligence processes is the subject of ongoing NSS development.

### Surveillance Architecture

(1) ***Representation of Surveillance Plan***
- Allocate resources (static + responsive).
- Minimize susceptibility to counterdetection.

(2) ***Representation of System Capabilities***
- Detectability spectrum.
- Dependence on mode, threat, environment.
- Reporting content and uncertainties.
- Reporting frequency.
- Susceptibility to counterdetection.

(3) ***Representation of Threat Susceptibility***
- Susceptibility spectrum.
- Dependence on operating profile, environment.
- Tactics to avoid detection.
- Tactics once detected.

### Communications Architecture

(1) ***Representation of Communications Plan***
- Dissemination rules.
- Backup/redundant routing.
- Minimize susceptibility to interception.
- Minimize susceptibility to disruption.

(2) ***Representation of System Capabilities***
- Connectivity and throughput.
- Dependence on environment.
- Susceptibility to interception.
- Susceptibility to disruption.

(3) ***Representation of Networks***
- Participation requirements.
- Protocols.
- Operating modes.
- Responsive re-allocation rules.

# C2 TERMS OF REFERENCE RESPONSES

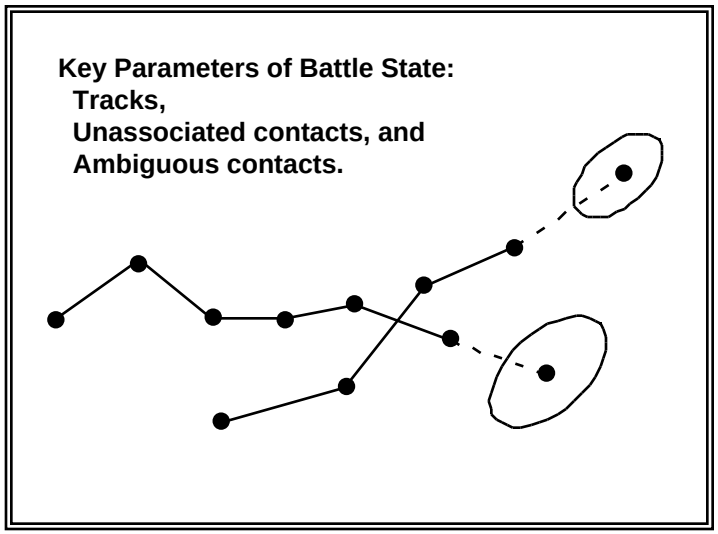
## I(2). Representation of Current Battle State

Military commanders act based upon a **perception** of the status of friendly, neutral, and hostile forces. This perception is formulated based upon the **information** available to the commander. NSS represents **each** commander's perception and simulates **all** commander decision-making based on this simulated perception.

**Commander's Simulated Tactical Picture**

**Surveillance Products**

Intelligence Products




**Domains:**
Air
Land
Ocean Surface
Undersea

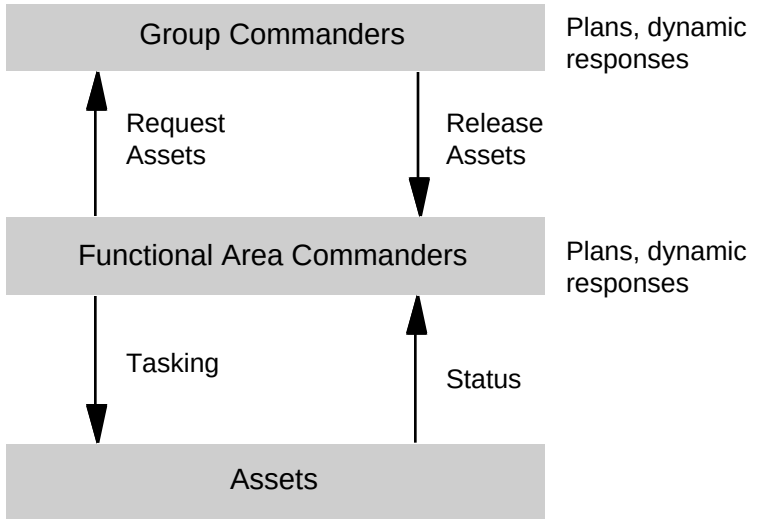
**Levels of Resolution:**
Perfect
DR, perfect correlation
DR, imperfect correlation
Kalman Filter

**Required Technologies:** Data Association / Correlation
State Estimation
Attribute Classification

# C2 TERMS OF REFERENCE RESPONSES

### I(3). Representation of Friendly Battle Plan

- Group Level Commanders
  - **Plans:** Group motion, priorities, reporting nets and circuits, readiness conditions, EMCON, weapon release status, UNREP, etc.
  - **Dynamic Responses:** Group level responses to I&W; e.g. change priorities, readiness conditions, EMCON, etc.
- Functional Area (WMA) Commanders
  - **Plans:** WMA specific plans; e.g. multi-phase strike plan, submarine search barrier operations plan, etc.
  - **Dynamic Responses:** Tactical responses to I&W plus responses to group commander directives.
- Asset Commanders
  - Plans and dynamic responses are provided by the commander(s) in tactical control (TACON) of the asset.



# C2 TERMS OF REFERENCE RESPONSES

## I(3). Level of Decision Representation

Group Commander Priorities vs. Time

(Example) WMA Priority Table

| | Default Conditions (Scenario Hrs) | | | | Exceptions | | | |
|---|---|---|---|---|---|---|---|---|
| **WMA** | 0 to 48 | 49 to 50 | 51 to 60 | etc | AAW Attack I&W | ASW Attack I&W | Mine I&W | etc |
| AAW | 3 | 4 | 2 | . | 1 | (current +1) | (current +1) | . |
| AMW | 8 | 8 | 8 | . | (current +1) | (current +1) | (current +1) | . |
| ASuW | 2 | 3 | 6 | . | (current +1) | (current +1) | (current +1) | . |
| ASW | 1 | 2 | 7 | . | (current +1) | 1 | (current +1) | . |
| LW | 9 | 9 | 9 | . | (current +1) | (current +1) | (current +1) | . |
| MCM | 4 | 5 | 4 | . | (current +1) | (current +1) | 1 | . |
| MIW | 5 | 1 | 5 | . | (current +1) | (current +1) | (current +1) | . |
| STW | 7 | 7 | 3 | . | (current +1) | (current +1) | (current +1) | . |
| TMD | 6 | 6 | 1 | . | (current +1) | (current +1) | (current +1) | . |

**Group Commander Priorities:**

A key element of each group commanders plan is the WMA priority table. This is used to resolve conflicts arising due to over-allocated assets.

# C2 TERMS OF REFERENCE RESPONSES

## I(3). Level of Decision Representation

- Example WMA Plan Format - Strike vs. Ashore Targets
  - Supports use of land- and/or sea-based attack and support aircraft, surface- and/or subsurface-launched land attack missiles, and Naval gun fire (NGF) support.
  - Strike plan elements:
    - **Phases:** Represent major elements of the strike, e.g. suppress coastal defenses. Phases include explicit damage goals. Phases may execute concurrently or sequentially. Phase initiation may depend upon successful completion of previous phase(s). Assessment of phase success or failure is dependent upon simulation BDA. Automated re-strike (given perceived damage shortfalls) capability is included.
    - **Missions:** Each phase is composed of mission(s). Mission types include: coordinated strike, strike interdiction, armed reconnaissance, stand-off jamming, fighter sweep, BDA collection, and land-attack cruise missiles.
    - **Groups:** Missions are executed by one or several group(s) of aircraft or missiles. Groups share common ingress corridors, egress corridors, and rendezvous times at key waypoints.
    - **Elements:** Groups are composed of elements, e.g. individual aircraft or missiles. Example element data is shown on the next slide.

# C2 TERMS OF REFERENCE RESPONSES

## I(3). Level of Decision Representation

- Strike Element Data Descriptions

| MISSION AREA | ELEMENTS | EXAMPLE ELEMENT ATTRIBUTES |
|---|---|---|
| Coordinated Strike | Strike aircraft | Target(s), detailed routes to each target, attack profile, weaponeering by target component. |
| | Fighter escort aircraft | Station(s), station duration, strike commander |
| | Jammer escort aircraft | Station(s), station duration, targets to jam, strike commander |
| Strike Interdiction | Strike aircraft | Interdiction region, time interval, prioritized target list, strike commander |
| Armed Reconnaissance | Strike aircraft | Reconnaissance region, search route, prioritized target list, strike commander. |
| Stand-Off Jamming | Jamming aircraft | Station(s), station duration, prioritized target list, strike commander |
| Fighter Sweep | Fighter aircraft | Station(s), station duration, strike commander |
| Battle Damage Assessment | Any aircraft | Station(s), station duration, targets to survey |
| Land-Attack Missiles | Cruise Missiles | Target, launch basket, detailed route to target, time on target |

# C2 TERMS OF REFERENCE RESPONSES

## I(4). Representation of Enemy Objectives

- The battle objectives of the enemy are known to simulated friendly commander's **only** through the outputs of simulated tactical pictures. Recall that simulated tactical picture outputs depend entirely on simulated sensor and situation reports.

- Enemy objectives or intentions are determined and acted upon through the use of dynamic response **decision tables**, e.g.
  - If enemy minelayers are observed within region R during time interval I, deploy mine countermeasures tactic T.
  - If n or more enemy fighter aircraft are observed inbound within range R of defended asset A, deploy CAP grid G with launch and recovery cycle C.

- More advanced treatments of intelligence processes (e.g. assessments of threat objectives/intent based upon more complicated considerations) are needed.

# C2 TERMS OF REFERENCE QUESTIONS

## II. DECISION PROCESS

- **Assessment of Current/Future Status.** How does your simulation represent the assessment of the perceived battle situation against the objectives of the commander at the decision level? Does your simulation attempt to project the future battle status and if so, how does this affect the simulated commander's decision process?
- **Decision Actions.** How are decision actions represented in your simulation? Are messages sent to from higher to lower echelons describing the decision with the appropriate response? Or are the decisions implicitly carried out by lower echelon units?
- **Dynamic/Reactive Decision Making.** Is the decision process represented in your simulation dynamic in nature? Do you simulate a commander's recognition of a battle situation, alter command battle objectives and exploit the situation? Or are decisions made in a reactive mode where simulated commanders try to maintain current battle objectives?
- **Doctrinal Context.** How is doctrinal context maintained in the simulated commander's decision process?

# C2 TERMS OF REFERENCE RESPONSES

## II(1). Assessment of Current/Future Status

- All simulated assessments of threat, neutral, and friendly forces are based upon the outputs of simulated tactical pictures available to the commander in question.

- Future battle status is projected using queries to the tactical picture in question. Some examples:
  - List all threat subsurface tracks which project to be within region R at future time t + T.
  - List all threat air tracks which project to be within range R of defended site S any time during time interval [t , t + T].

- Planned as well as responsive actions can be predicated upon such queries.

# C2 TERMS OF REFERENCE RESPONSES

## II(2). Decision Actions

- All decision actions are represented via explicit simulated message passing over simulated communications systems/nets in accordance with the relevant communications plan.

- Types of decision actions modeled include:
  - Group commander orders subordinate commanders/assets to change motion, readiness conditions, EMCON status, weapon release status, etc.
  - WMA commander requests assets (or specific asset capabilities) from group commander.
  - Group commander releases assets (or specific asset capabilities) to WMA commander.
  - WMA commander tasks subordinate assets to intercept, conduct search and surveillance, engage, jam, etc.
  - Asset reports (system) status to WMA commander.

- Assets can process multiple (non-conflicting) orders in parallel.

# C2 TERMS OF REFERENCE RESPONSES

## II(3). Dynamic/Reactive Decision Making

At the group commander level and below, decision making is fully dynamic/ reactive for an enumerated set of decision making situations. An example:

| Dynamic Tactical Response Table | | | | |
|---|---|---|---|---|
| **{COMMANDER TYPE, TRIGGER TYPE}** | | | | |
| Operational Applicability: | {Commander Subtype(s) and/or Instances(s)}<br>{Command & Control Mode(s)}<br>{Mission Type(s)}<br>{Attack Readiness Condition(s)}<br>{Scenario Time Interval(s)}<br>{Scenario Phase(s)} | | | |
| **Tactical Trigger Conditions** | Dynamic Responses | | | |
| | **Response Type 1** | **Response Type 2** | • | **Response Type n** |
| {Condition Set 1} | { Priority; Criteria; Action(s)} | { Priority; Criteria; Action(s)} | • | { Priority; Criteria; Action(s)} |
| {Condition Set 2} | { Priority; Criteria; Action(s)} | { Priority; Criteria; Action(s)} | • | { Priority; Criteria; Action(s)} |
| • | • | • | • | • |
| {Condition Set n} | { Priority; Criteria; Action(s)} | { Priority; Criteria; Action(s)} | • | { Priority; Criteria; Action(s)} |

**Example Trigger Conditions:**
- Detect SA-10 lock-on
- Detect > 3 Mirage 2000's

**Example Criteria**:
- Within region
- Within range

**Example Responses**:
- Message routing plan
- Motion modification plan
- Engagement package

# C2 TERMS OF REFERENCE RESPONSES

## II(4). Doctrinal Context

- User specified **plans** and dynamic response **decision tables** define the scripts and rules by which the decision process is simulated.

- Each plan has a well-defined context; e.g. strike warfare. These often closely mirror operational order formats, e.g. air tasking orders (ATOs).

- Each decision table also applies to a specific doctrinal context; e.g. anti-air warfare commander (AAWC) on CG-52 receives a specific I&W report.

- Each decision table has a well-defined context; e.g. AAWC conducting BG air defense. These often closely mirror published tactical procedures; e.g. fighter squadron tactical procedure (TACPRO) memoranda.

# C2 TERMS OF REFERENCE QUESTIONS

III. SIMULATED SUPPORT TO THE DECISION PROCESS

- **Sensor support.** How do simulated sensor reports impact the simulated decision process in your simulation? Do they provide enemy status (location, resource estimate etc)? Do they also provide input to the simulated commander's perception of enemy intent?
- **Information operation activities.** Does your simulation also represent the impact on the simulated commander's decision process of real-time information on the status of friendly forces?

# C2 TERMS OF REFERENCE RESPONSES

## III(1). Sensor Support

- Simulated sensor reports are routed via user defined **communications plans** to commanders where they are processed into simulated **tactical pictures**.
- Simulated tactical pictures provide each commander with a **perception** of threat, neutral, and friendly forces.

## III(2). Information Operation Activities

- As an option, friendly forces can routinely report position and status information to cognizant commanders.
- This information can be fused with friendly force detection data into appropriate tactical pictures.
- BLUE-on-BLUE engagements can be explicitly simulated.

# C2 TERMS OF REFERENCE QUESTIONS

## IV. ARCHITECTURAL ASPECTS OF SIMULATIONS REPRESENTING INFORMATION OPERATIONS

- **Command Levels at which Live Battle Staffs can be Used in the Simulation?** At what echelon (or echelons) can a live command staff enter the simulated battle environment? How are the command and control processes represented for simulated subordinates reporting to these live staffs and for superiors directing these live staffs?
- **Required Levels of Fidelity.** What are the required levels of fidelity simulated (individual/aggregate command nodes represented, communication systems represented, sensor systems represented etc.) to provide the environment supporting your simulated command decision process? What is the minimum level of fidelity (in sensors, command nodes, communications) required to trace a causal relationship between battle activity and a simulated command decision?

# C2 TERMS OF REFERENCE RESPONSES

**IV(1). Command Levels at which Live Battle Staffs can be Used in the Simulation?**

- NSS is currently constructive only; i.e. simulated commanders operating simulated systems/forces.
- In FY-96 NSS will be extended to permit live interactions at the group or WMA commander levels.
- Targeted user group is OPNAV N81 and J-8/WAD for analyst-in-the-loop operations.

**IV(2). Required Levels of Fidelity**

- NSS provides user selectable levels of fidelity:
  - **Fusion:** Perfect, DR with perfect correlation, DR with imperfect correlation, Kalman Filtering
  - **Comms:** Assured with delays, unassured, specific (protocols)
  - **Sensors/CMs:** Simple parametric, detailed parametric, specific (energy mgmt, etc.)
  - **Weapons:** Simple parametric, detailed parametric, specific (kinematics, etc.)
- Representation of individual commanders is also required in order to evaluate detailed C2 alternatives.

# C2 TERMS OF REFERENCE QUESTIONS

V. OTHER ISSUES

- **Primary Issues.** What are the primary issues you are currently facing simulating the decision making process?
- **Required Research Areas.** Are there areas that you feel theoretical research needs to be conducted?
- **New Applications.** Are there areas where you feel important applications can be developed given time and funding?

# C2 TERMS OF REFERENCE RESPONSES

**V(1). Primary Issues**

- Campaign-level dynamic decision making (e.g. responsive changes to high-level objectives and plans). Can this be simulated constructively? Is MITL required?
- INTEL processes. To what extent can highly multi-data-source, highly cognitive INTEL assessment processes be simulated?
- Resource contention. To what extent can highly complex (CVBG-level or higher) contended resource allocation decisions be simulated? Is a simple priority-based scheme good enough?
- Traceability. How does the analyst assess the impact of alternate decision strategies on the simulated outcome?

**V(2). Required Research Areas**

- Assess the tradeoffs between comprehensibility/simplicity and generality. Are decision tables "good enough"? Are more exotic AI-based knowledge representation approaches needed and feasible?

**V(3). New Applications**

- OPLAN generation/reading tools for all services. To the extent possible, simulations should read in and output operational plans (e.g. ATO's, ITO's, etc.) in standard military formats. General tools supporting this process are needed.

# SUMMARY

- NSS is a constructive (virtual) simulation which explicitly models complex command structures, operational plans and tactics, tactical picture generation (perception), surveillance, and communications.

- C2 decision process modeling in NSS is largely scripted at the National/Theater levels but is fully dynamic and reactive at the Force/Unit levels.

- Commander behavior is specified (by the analyst or fleet user) via formatted **plans** and dynamic response **decision tables**.

- NSS supports the explicit assessment of the impact of alternate decision strategies on the simulated engagement outcome.